KYANITE

By Michael J. Potter

Kyanite, and sillimanite are anhydrous aluminum silicate minerals that have the same chemical formula, Al₂O₃·SiO₂, but differ in crystal structure and physical properties. When calcined at high temperatures, these minerals are converted to mullite, $3Al_2O_3 \cdot _2SiO_2$, and silica, SiO_2 , which are refractory materials. Andalusite and sillimanite are not produced in the United States, except for a pyrophyllite/ andalusite/sericite deposit that is mined by Piedmont Minerals Co., Inc., near Hillsborough, NC. In processing the ore, and alusite is not separated but remains in various combinations with the pyrophyllite and sericite to produce blends of products. Some examples of end-uses of the company's products include refractories; whitewares, such as tile and sanitaryware; and structural ceramics, including earthenware and stoneware. South Africa and France are the main producing countries of andalusite. India has been the largest producing country of sillimanite with an estimated 10,000 metric tons in 1996. (See table 4.)

Iron and steelmaking is the largest end use for refractories in general. "Clean steelmaking" is said to put increasing demands on refractories. "Clean steel" contains low amounts of oxide and sulfide impurities, nitrogen, hydrogen, and carbon. The production of "clean steel" is now commonly done by ladle metallurgy. In the past, ladles, which have refractory linings, were mainly used for transport of molten steel, but increasingly, they are secondary metallurgical reactors. Originally, the main function of the ladle refractory lining was to minimize temperature loss, but now it must resist increased chemical attack (Semler, 1996, p. 37).

Production

Kyanite was mined at two open-pit locations by Kyanite Mining Corp. in Buckingham County, VA. The company also operated beneficiation plants and calcining facilities for conversion of kyanite to mullite. High-temperature sintered synthetic mullite was produced by C-E Minerals at Americus, GA, and North American Refractories Co. at Greenup, KY. Data were obtained for the kyanite and both synthetic mullite producers but cannot be published because of their proprietary nature.

Consumption

The U.S. Geological Survey does not collect data on end uses of kyanite and synthetic mullite. However, refractories were a major end use, including monolithics such as ramming mixtures, castables, gunning mixes, and plastics. Some other end uses were whitewares, kiln furniture, acoustical tiles, catalytics, electrical insulators, shell castings, foundry uses, and investment casting procedures.

Foreign Trade

Shipments of U.S. kyanite, mullite, and synthetic mullite were made to worldwide locations including Europe, Latin America, the Pacific Rim, and other countries. In recent years, imports of andalusite have been largely from South Africa. There were no known U.S. imports of kyanite or sillimanite in 1996.

World Review

Capacity.—Because actual capacity data were generally not available, the data in table 3 are estimated for marketable product at yearend 1996. For most countries, capacity was considered to be the same as the highest production during the past 5 years.

China.—The Henan Xixia Andalusite Mine in Henan Province, China, was believed to be constructing a new processing plant. The capacity would be about 200,000 tons per year of ore, yielding about 10,000 tons per year of andalusite product. The other Chinese producer, Shandong Wulian Andalusite Mine, in Shandong Province, was producing about 3,000 tons per year. Chinese material was said to have a higher iron content than South African material (Skillen, 1996, p. 63-64).

South Africa.—Anglovaal Minerals announced plans to reopen its mothballed Havercroft andalusite mine in Northern Province. Capital costs of reestablishing the mine and upgrading the processing plant were estimated to be \$9.4 million. Production was projected to restart in the second quarter of 1997. Annual production capacity was planned to be about 60,000 tons, and the bulk of the output was slated for export to refractories manufacturers worldwide. Production from Havercroft would supplement Anglovaal's existing andalusite production from its Rhino Andalusite Mines Ltd. subsidiary near Thabazimbi, also in Northern Province. The Rhino Mine was producing about 120,000 tons per year, about half of which was being exported (Industrial Minerals, 1996, p. 16).

The other South African producers of andalusite were Samrec Pty. Ltd., a wholly owned subsidiary of French refractory clay and andalusite producer Damrec, and Hoogenoeg Andalusite Pty. Ltd. Samrec was operating three mines in South Africa with a total capacity of 125,000 tons per year.

Hoogenoeg, with a capacity of 36,000 tons per year, was havingk its assets purchased by Hernic Exploration Pty. Ltd. (McCracken and Kendall, 1996, p. 53-54).

Outlook

Monolithic refractories were being used in a growing number of ways especially because of the availability of advanced castables, self-flow castables, improved gunning materials, and other developments. However, according to one refractories consultant, the total U.S. market value of all refractories may decline from 2% to 9% by the year 2000 as continuous improvement and longer life of refractories result in lower growth of sales and production. In environmental matters, refractory companies throughout the world could take an active role in the removal, handling, disposal, and recycling of used refractory linings. In the global marketplace, several U.S. companies had opened plants in other countries. Opportunities could arise for companies to improve profitability by taking advantage of niche markets and expanded international business (Ceramic Industry, 1996, p. 58-59).

In Europe, steel production was growing at a rate of about 3% per year. Andalusite-based castable refractories were finding use in a number of steel plant applications. Zircon, metal powders, silicon carbide, and other materials can be added to andalusite-based castables to enhance their properties in corrosive environments. There was some evidence of growth in the aluminum- and glass-manufacturing sectors. Eastern Europe was believed to offer market potential as improvements in steel production promote the use of more efficient refractory materials (Skillen, 1996, p. 65-67).

References Cited

Ceramic Industry, 1996, Short term future of refractories looks strong: Ceramic Industry, v. 146, no. 9, p. 58-59.

Industrial Minerals [London], 1996, World of minerals: Industrial Minerals, no. 347, p. 16.

McCracken, W.H., and Kendall, T., 1996, Andalusite review 1995: Industrial Minerals, no. 346, p. 53-54.

Semler, C.E., 1996, Global development of refractories: Ceramic Industry, v. 145, no. 2, p. 37.

Skillen, A., 1996, Market overview—Sillimanite minerals: Industrial Minerals, no. 350, p. 63-65, 67.

SOURCES OF INFORMATION

USGS and USBM Publications

Kyanite and related materials. Ch. in Mineral Commodity Summaries, annual.

Kyanite and related minerals. Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820.

Kyanite and related minerals. Ch. in Mineral facts and problems, U.S. Bureau of Mines Bulletin 675.

Other

Roskill Information Services Ltd., 1990, The economics of kyanite 1990 (6th ed.): London, 118 p. plus appendixes.

Sweet, P.C., 1994, Sillimanite group—Kyanite and related minerals, in Carr, D.D., sr. ed., Industrial minerals and rocks (6th ed.): Littleton, CO, Society for Mining, Metallurgy, and Exploration, Inc., p. 921-927.

TABLE 1 PRICE OF KYANITE AND RELATED MATERIALS

(Dollars per metric ton)

1996	Price
Andalusite, Transvaal, 57.5% Al2O3, 2,000 metric ton bulk, f.o.b.1/	180 - 200
Andalusite, Transvaal, 59.5% Al2O3, 2,000 metric ton bulk, f.o.b.	220 - 240
U.S. kyanite, 54% to 60% Al2O3, 35-325 mesh, 18-ton lots, f.o.b. plant:	
Raw	140 - 168
Calcined	248 - 276
Sillimanite, South African, 70% Al2O3, bags, c.i.f. 2/ main European port	296
4 / 1055	

^{1/ &}quot;Free-on-board".

Source: Industrial Minerals (London), December, 1996, No. 351, p. 73.

 ${\bf TABLE~2} \\ {\bf U.S~IMPORTS~1/~FOR~CONSUMPTION~OF~ANDALUSITE~2/} \\$

	Quantity	Value 3/
Year	(metric tons)	(thousands)
1995	3,210	\$623
1996	11,300	2,310

^{1/} Most material is from South Africa.

Source: Bureau of the Census.

^{2/ &}quot;Cost, insurance, and freight."

^{2/} Harmonized tariff schedule (HTS) number: 2508.50.0000.

^{3/} Customs value.

TABLE 3 WORLD KYANITE AND RELATED MINERALS CAPACITY DECEMBER 31, 1996

(Thousand metric tons)

World region/mineral	Capacity 1/		
North America:			
United States:			
Kyanite	W		
Synthetic mullite	W		
Total	W		
South America:			
Brazil: Kyanite	1 e/		
Europe:			
France: Andalusite	50 e/		
Germany: Synthetic mullite	15 e/		
Spain: Andalusite	5 e/		
United Kingdom: Synthetic mullite	10 e/		
Other countries	120 e/		
Total	200 e/		
Africa:			
Kenya: Kyanite	(2/) e/		
South Africa:			
Andalusite	300 e/		
Sillimanite	1 e/		
Zimbabwe: Kyanite	2 e/		
Total	303 e/		
Asia:			
China: Unspecified	3 e/		
India:			
Kyanite	11 e/		
Sillimanite	19 e/		
Total	30 e/		
Japan: Synthetic mullite	40 e/		
Total	73 e/		
Oceania:			
Australia:			
Kyanite	1 e/		
Sillimanite	(2/) e/		
Total	1 e/		
World total 3/	578 e/		

e/ Estimated. W Withheld to avoid disclosing company proprietary data.

1/ For many countries, capacity is commensurate with their highest production during the past 5 years. (See table 4.)

^{2/} Less than 1/2 unit.

^{3/} Excludes U.S. kyanite and synthetic mullite.

TABLE 4 KYANITE: WORLD PRODUCTION, BY COUNTRY 1/2/

(Metric tons)

Country 3/ and commodity	1992	1993	1994	1995	1996 e/
Australia: e/					
Kyanite	800	800	800	800	800
Sillimanite 4/	100	100	100	100	100
Brazil: Kyanite e/	600	600	600	600	600
China: Unspecified e/	2,500	2,500	2,500	2,500	2,500
France: Andalusite e/	50,000	50,000	50,000	45,000 r/	45,000
India:					
Kyanite	10,101	11,359	6,265 r/	6,705 r/	7,000
Sillimanite	18,837	14,895	10,378 r/	9,705 r/	10,000
Kenya: Kyanite e/	(5/)	(5/)	(5/)	(5/)	(5/)
Korea, Republic of: Andalusite	38	18 r/	r/	r/	
South Africa:					
Andalusite	230,333	187,708	206,291 r/	209,735 r/	210,000
Sillimanite	632	569	525 r/	317 r/	400
Spain: Andalusite e/	3,600	3,000	3,500	3,500	3,500
United States:					
Kyanite	W	W	W	W	W
Mullite, synthetic	W	W	W	W	W
Zimbabwe: Kyanite	1,990	878	567	600 e/	600
•	•				

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

 $^{1/\}operatorname{Estimated}$ data are rounded to three significant digits.

^{2/} Owing to incomplete reporting, this table has not been totaled. Table includes data available through Mar. 20, 1997.

^{3/} In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

⁴/In addition, about 7,000 metric tons of sillimanite clay (also called kaolinized sillimanite) is produced annually containing 40% to 48% Al2O3.

^{5/} Less than 1/2 unit.